Comparison of the Long-term and Short-term Fluctuations of Frequency-Doubling Technology Perimetry Between Peripheral and Paracentral Zones of Visual Field

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ABSTRACT

Objective: To compare the long- and short-term fluctuations of frequency doubling technology perimetry between peripheral and paracentral zone and determine the relationship between threshold sensitivity and long- and short-term fluctuation within peripheral and paracentral zone of visual field.

Study Design: Descriptive study.

Place and Duration of Study: Eye Department, United Nations, Pakistan Field Hospital Level-3 Darfur, Sudan, from February to July 2015.

Methodology: Normal eyes of 30 volunteers were recruited. Frequency doubling technology perimetry, program N-30, full threshold was employed. Each subject was tested at weekly intervals, once in the 1st, 3rd and 4th sessions and three times in the 2nd session. Visual field was divided into paracentral, superior, and inferior zones. Short-term and long-term fluctuation as well as threshold sensitivity were calculated for each patient as the mean fluctuation and mean sensitivity value. Mann-Whitney U-test was used to compare each zone in terms of their short- and long-term fluctuations and Spearman's rho correlation test for determining the relationship of threshold sensitivity with short- and long-term fluctuations.

Results: Long-term fluctuation values differences were insignificant between superior and paracentral zones. Short-term fluctuation values were statistically insignificant between all three zones. Short-term fluctuation and threshold sensitivity in each zone did not correlate. Long-term fluctuation and threshold sensitivity had a very weak negative, statistically insignificant correlation in superior and paracentral zones.

Conclusion: Frequency doubling perimetry exhibits uniform short- and long-term fluctuations in peripheral and paracentral zones of visual field in normal subjects. Threshold sensitivity and long- and short-term fluctuations are independent of each other in peripheral and paracentral zones of visual field.


INTRODUCTION

Automated perimetry is an essential tool in glaucoma management even with advances in imaging technologies, for the reason that there is poor correlation between structure and function of the optic nerve. However, it has substantial limitations among which is the test-retest variability.¹,²

This perimetric variability has two components, the long-term and short-term fluctuations.³ Long-term fluctuation (LTF) or inter-test variability is defined as the variability in threshold values among examinations performed over time, corrected for short-term fluctuation in the absence of clinically detectable pathology.⁴ This variability is the most common reason for a false positive follow-up field in glaucoma.⁵ Short-term fluctuation (STF) is computed from the variability of threshold values found on repeated measurements during the same examination.⁴ Compared to standard automated perimetry (SAP), the frequency doubling technology (FDT) perimeter is not only better than SAP in detecting visual field (VF) loss earlier, but it is also better in detecting future glaucomatous damage.⁶,⁷ FDT perimetry has a sensitivity of 85% with 90% specificity in the detection of early glaucoma.⁸

FDT perimetry is a psychophysical test and it is inherent in any psychophysical test to produce fluctuation in the results during subsequent examinations because the ability of the eye to detect a stimulus at threshold levels does not obey the all or none law.⁹ Consequently, the LTF and STF components affect the threshold sensitivity detected by FDT perimetry.¹⁰

One of the attributes for any perimetric test is that the threshold variability should not change with eccentricity of the visual field.¹¹ In FDT perimetry, there is no increase in LTF in the peripheral visual field locations in normal as well as glaucoma patients.¹¹ This makes FDT
more convenient in detecting real glaucomatous changes in peripheral field locations.11

There is only one published study that has specifically evaluated the role of eccentricity on LTF, using FDT perimetry with the C-20 full threshold programme.11 The authors, therefore, selected the N-30 full threshold programme which expands the nasal field up to 30 degrees and divided the VF into peripheral (superior, inferior) and paracentral zone. Moreover, the effect of eccentricity has been studied on LTF only without quantifying the role of STF in affecting the total variability.4

The objective of this study was to compare the long- and short-term fluctuations of FDT perimetry between peripheral and paracentral zones of visual field and determine relationship between sensitivity and fluctuation within each zone in healthy subjects.

METHODOLOGY

This descriptive study was conducted at the Eye Department of United Nations, Pakistan Field Hospital Level-3 in Darfur, Sudan, from February to July 2015. The sample size was calculated on the basis of the known standard deviation value (σ = 1.24) decibels of mean threshold sensitivity of visual field of healthy subjects,10 by applying the formula \((Zα + Zβ)^2 \cdot σ^2 / δ^2\). The level of significance was 95% (α=0.05) and power of the test was 90% (β=0.10), and margin of error was 5% (δ=0.05). The calculated sample size was 13 but to further increase the power of the test, a sample size of 30 was selected. Using the convenience sampling method, 30 eyes of 30 healthy consecutive volunteers fulfilling the inclusion criteria were recruited from the hospital staff. Written informed consent was obtained from all the volunteers. The study was approved by the Ethical Review Board Committee of Pakistan Field Hospital. Ophthalmic examination included visual acuity test, manifest refraction, slit lamp examination, applanation tonometry, gonioscopy and dilated fundoscopy. Inclusion criteria were subjects aged 20 years or older, corrected visual acuity of 6/9 or better, clear ocular media, a cup-to-disc ratio 0.4 or less, an open-angle, spherical refraction within plus or minus 5.0 D, and cylinder correction within plus or minus 3.0 D. Subjects were excluded if they had an intraocular pressure of more than 21 mmHg in either eye, suspicious appearing optic disc (i.e. localised rim loss, optic disc haemorrhage, cup disc asymmetry >0.2), history of any ocular disease, surgery or trauma, abnormal pupillary examination or history of miotic use, or other medications use that might affect pupil size and visual field sensitivity.

The right eye was selected for testing in all the subjects and throughout all the examinations. Perimetry was performed with the Humphery frequency doubling technology perimeter (Welch Allyn, Skaneateles, New York and Humphery Systems, Dublin, California) under dark room conditions. The N-30 full threshold strategy was chosen. This strategy consists of a plot of 19 visual field locations and the area of field being tested is 20 degrees temporally and vertically; while nasally up to 30 degrees from the central fixation point, respectively. Each subject received a brief explanation about testing, about the device and the examination procedure, including a short demonstration of frequency doubling phenomenon. They were repeatedly asked to do their best at each and every examination. During the test, the catch trials were constantly monitored and; therefore, only that field was selected for analysis in which the reliability limit was under 33% for false positive and negative error and 20% for fixation losses.

Each subject underwent a total of six field examinations which were divided into long- and short-term session. For the long-term session, four field examinations and therefore, four patient visits were scheduled at weekly intervals. For the short-term session, the second visit of the patient was selected. At the second visit, each patient was scheduled to undergo three visual field tests at 30-minute interval in one day. The first field test of the second visit was also included for the long-term session. Out of the 19 points in each visual field, 18 points were divided into 03 zones comprising of four points in paracentral and seven points each in superior and inferior zones, respectively. The central fixation point was not included for analysis. Threshold sensitivity at each of the 19 points was recorded for all the long- and short-term sessions of each patient.

Then the mean threshold sensitivity of all the points in a particular zone was calculated for each subject for each session. To calculate fluctuation, the mean difference in threshold sensitivity between examinations was calculated in that particular zone of each patient. Then the mean value of this difference of all the points in that zone was calculated as the mean fluctuation of that zone. For the long-term fluctuation, these values were recorded over a period of 01 month from the 04 consecutive sessions at weekly intervals; and for short-term fluctuation, the values were recorded from the 03 visual field tests performed on the same day at 30-minute interval at the 2nd session of the patient.

Statistical analysis was performed using SPSS version 20.0. Descriptive statistics were used to describe the age, long- and short-term threshold sensitivity and fluctuations in each zone. Median (IQR) values were used for numerical data. Mann-Whitney U-test was selected for comparison of variables. To perform the Mann-Whitney U-test, the median values of long and short-term fluctuations of each patient were used to compare long- and short-term fluctuations between the zones (interzone) and also to compare the long-term with the short-term fluctuation within each zone.
(intrazone). To determine a relationship between threshold sensitivity and long- and short-term fluctuations in the same zone, the Spearman's rho correlation test was selected. A p-value less than 0.05 was considered to be statistically significant.

RESULTS

Median (IQR) age of the patients was 34.5 (8.0) years. All patients were male. The median (IQR) of long-term fluctuation in the superior, inferior, and paracentral zones were 1.24 (1.23) dB, 1.03 (0.66) dB and 1.33 (0.98) dB, respectively. The long-term fluctuation was statistically significantly higher in the paracentral zone when compared with the inferior zone only (p=0.02). There was no significant difference in the long-term fluctuation between superior and inferior zones (p=0.02), and superior and paracentral zones (p=0.72, Table I).

In the short-term analysis, the median (IQR) fluctuation in the superior, inferior and paracentral zones were 1.07 (1.03) dB, 0.88 (0.79) dB and 0.87 (1.03) dB, respectively. Interzone analysis of long- and short-term fluctuations showed that the differences in the values between the zones were statistically insignificant (Table I).

Comparison of the long- and short-term fluctuations within each zone showed that the paracentral zone exhibited a statistically significant greater long-term fluctuation than the short-term fluctuation (p=0.02). There was no statistically significant difference between the long- and short-term fluctuations in either the superior (p=0.27) or inferior zones (p=0.24).

Relationship of the threshold sensitivity and long-term fluctuation in each zone showed that for the superior and paracentral zones, there was a very weak negative correlation which was statistically insignificant (Table II). In the inferior zone, the long-term fluctuation and sensitivity revealed a weak negative correlation which was statistically significant (rs=-0.39, p=0.03) and as shown in Table II.

Analysis of the relationship of short-term fluctuation and threshold sensitivity in each zone revealed that in the paracentral zone there was a very weak negative correlation which was statistically insignificant (rs=-0.14, p=0.45). In the superior and inferior zones, the short-term fluctuation and threshold sensitivity did not correlate with each other (Table III).

DISCUSSION

It is a well known fact that visual sensitivity reduces from the centre to the peripheral points in automated perimetry, with fovea having the highest ability to detect the least intense stimulus; and then this function progressively decreases towards the periphery, where it is the minimum. Therefore, the more peripheral is the location of the stimulus, the more is the intensity required to perceive it in normal individuals. Similarly, the threshold sensitivity in normal eyes detected by FDT for points farther from fixation tends to reduce as the eccentricity of the visual field increases. Horani et al. reported that the 04 paracentral grid points had significantly greater sensitivity than the 12 peripheral grid locations in healthy subjects, and the superior hemifield with its eight points had greater sensitivity than the inferior hemifield throughout the six tests done over a period of 03 weeks. This study differs with the previous studies in this respect that we have studied the characteristics of threshold sensitivity across long-term as well as short-term sessions. With this technique, the results of this study are in agreement with the previous data as we found that the paracentral zone had greater sensitivity than the superior and inferior zones over both the long- and short-term assessments. With respect to hemifield sensitivity comparison, the values were similar between the superior and inferior hemifields. Our findings suggest that the sensitivities in various zones were not affected by the long-term and short-term sessions.

The LTF of SAP in normal subjects varies from 1-2 dB centrally to 4-6 dB at 27 degrees of eccentricity. This increased variability in the periphery is statistically significant when compared with the paracentral zone even at 20 degrees of eccentricity. Review of literature on eccentricity-based LTF values for FDT perimetry reveals that although the LTF in the peripheral field locations has been compared with the paracentral zone, but the actual values have not been described.
Moreover, the eccentricity in these analyses was up to 20 degrees around fixation. With a limited sample size, our results mention the actual values of LTF in a zone-wise manner comprising of superior, inferior, and paracentral zones with 20 degrees of vertical and temporal eccentricity and 30 degrees of nasal eccentricity. The LTF in this study did not increase in the peripheral zones; and moreover, the values were lower than the paracentral zone. Comparing this result with a similar study done by Chauhan et al.,¹¹ the results of this study support his findings but differ in that we tested 14 peripheral field locations instead of the 12 locations, thus adding further refinement to the previously published data.

The STF values of healthy subjects published in previous studies vary from 1.72 ±0.38 dB to 2.16 ±0.5 dB with the N-30 and C-20 threshold programmes, respectively.¹⁰,¹⁹ Analysis of these and other studies on FDT perimetry reveals that the influence of eccentricity on the STF has not been touched upon.¹⁰,¹¹,¹⁸-²⁰ The authors, therefore, recorded the STF values with respect to superior, inferior, and paracentral zones. Furthermore, on comparing these STF values between each zone the results showed that eccentricity did not affect the short-term fluctuation.

Threshold sensitivity and variability in SAP in glaucomatous eyes have been found to be dependent on each other. For example, Wall et al. observed that variability increased dramatically with decreasing sensitivity in glaucomatous eyes; but in normal subjects, there was no such relationship.³ Contrary to SAP, Spry et al. found that in FDT perimeter sensitivity and variability behaved independently of each other in normal as well as in glaucomatous eyes.¹⁸ Additionally, Spry also reported that sensitivity did not correlate with inter test and intratest variabilities in normal and glaucomatous eyes.¹⁸ The present study confirms the findings of previous studies but the results are unique with regard to eccentricity. With eccentricity acting as a possible confounder, it was found that eccentricity did not affect the independent relationship of inter test and intratest variabilities with sensitivity. The large stimulus size used by FDT perimeter is the cause that eccentricity did not affect variability.³

Total fluctuation is a compound measurement of short and long-term fluctuations.¹⁷ Spry observed that STF contributed significantly more to the total fluctuation than LTF in normal individuals with FDT perimeter.¹⁸ Comparison of the STF and LTF values in each zone in the present study depicted the values to be statistically insignificant. This suggests that both components had contributed equally to the total fluctuation. These findings are not in agreement with the published data.¹⁷,¹⁸ One explanation for this disagreement is that we did not correct the values of LTF for the STF values as STF affects the heterogeneous component of LTF.¹⁷ Every instrument has a finite dynamic range for detection of threshold sensitivity. As a result of this finite range when an instrument detects sensitivity in an area that has an advanced damage, the measured variability is artifACTually truncated in that location making it difficult for the clinician to differentiate a true change from physiological variation.³,¹¹ Therefore, uniform variability in areas of VF damage is desirable from an instrument to detect a VF change.³ FDT perimeter in this regard has proved to be better than SAP. Our results show that FDT perimeter exhibits uniform physiological variation in sensitivity from central to peripheral field locations. This make, it a useful tool for detecting a glaucomatous change in peripheral field locations.

**CONCLUSION**

Frequency doubling technology perimetry exhibits uniform short and long-term fluctuations in peripheral and paracentral zones of visual field in normal subjects. Threshold sensitivity and long- and short-term fluctuations are independent of each other in peripheral and paracentral zones of visual field.

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